DOCUMENT RESUME

ED 228 204 SP 022 048

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TITLE The Acute Effect of Aerobic Exercise on Measures of Stress.
PUB DATE [78]
NOTE 11p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Adults; Anxiety; *Exercise; *Exercise Physiology; Motor Reactions; Physical Activity Level; *Physical Health; *Physiology; Sex Differences; *Stress Variables
IDENTIFIERS *Aerobics; Palmar Sweat Print Method; State Trait Anxiety Inventory

ABSTRACT

The immediate response of stress to aerobic exercise was measured by utilizing the Palmar Sweat Index (PSI) and the State-Trait Anxiety Inventory (STAI). Forty subjects (20 male and 20 female) from the ages of 18-30 sustained a single bout of aerobic activity for 30 minutes at 60 percent of their maximum heart rate. Pre-treatment procedures included administration of the STAI and obtaining a finger print for determining enumeration of open sweat pores. Each subject's resting heart rate was then determined so that the treadmill could be adjusted until the target heart rate was reached. After the half-hour exercise period, the STAI was readministered to each subject, and a second fingerprint was taken to measure the number of open sweat pores. Results showed a significant decrease in both psychological stress as measured by the STAI and in physiological stress as measured by the PSI. (JM)

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The lifestyle of the average American is filled with stress and different people react to stress in different ways. The body requires a certain amount of stress for motivation and satisfaction of needs, but excessive negative stress can have a detrimental effect on health. Positive forms of stress can counteract the negative forms and, more and more, people have been using exercise to help them cope with the demands of daily living in a fast-paced society. Physical activity has been frequently prescribed as a means of reducing tension.3 There is, however, a lack of information, specifically concerning intensity and duration, relating to the acute effects of exercise on feelings of stress.10

Stress has been measured from both a physiological and a psychological standpoint. One such physiological measure has been the Palmar Sweat Index, which recognizes two basic types of sweating -- thermal and mental. Thermal sweating occurs on all skin surfaces except the palms of the hands and the soles of the feet. Sweating as a result of temperature changes or exercise and sweating in the palms and soles as a result of mental or emotional stimuli are distinct physiological responses.8 The Palmar Sweat Index, developed by Harrison and Mackinnon, yields the number of functioning sweat glands in a four square millimeter area around the central whorl of the finger tip.6 Several investigators have

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used this method to measure stress. 9,11,13,15 Repeated prints have been taken from subjects less than a minute apart with significant changes. PSI scores are expressed as changes from previous scores, deviations from an individual's mean, or deviations from a baseline. Although a physiological indicator such as the PSI cannot describe the subtleties of a psychological state as completely as honest conceptual expression, the Palmar Sweat Index may detect changes which a subject may not reveal verbally.7

Stress may also be reflected psychologically as anxiety, which is defined as a troubled feeling or a sense of dread or fear to a real or imagined situation that imposes on one's mental or physical well-being.14 The State-Trait Anxiety Inventory was developed to measure the two distinct components of state and trait anxiety. State anxiety is a temporary condition of self-perceived feelings of tension which fluctuate in intensity over a period of time. It refers to a reaction taking place at a particular point in time. In contrast, trait anxiety is a more stable "anxiety proneness" characteristic of the individual.12 The STAI has been reviewed as one of the best, if not the best, of standardized measures.4 Several investigators have utilized the STAI before and after periods of physical acitivity.1,2,5

PURPOSE OF STUDY

The purpose of this study was to investigate the immediate response of stress as measured by the Palmar Sweat Index and the State-Trait Anxiety Inventory to a single bout of aerobic activity sustained for 30 minutes at 60% of the maximum heart rate.

RESEARCH PROCEDURES

Subjects were 40 volunteers -- 20 males and 20 females -- from the ages of 18 to 30. Potential subjects were provided with an explanation of procedures and a written informed consent. Each subject provided information as to the type, duration and frequency of his or her physical activity plus details concerning the use of prescription drugs, cigarettes and alcohol.

Pre-treatment procedures included administration of the State-Trait Anxiety Inventory (Forms X-1 and X-2), explained as a self evaluation questionnaire, and obtaining a print from the third finger of the nondominant hand for the enumeration of open sweat pores. Subjects were then connected by five leads to a Burdick EKG and sat quietly for a period of five minutes to determine resting heart rate. Each subject then began exercise on the treadmill to last for a period of 30 minutes at a heart rate, which was determined by subtracting the resting rate from the age-predicted maximum heart rate, multiplying by 60% and adding the value of the resting rate. The speed of the treadmill was adjusted according to the EKG readout of the heart rate of the subject, so that each person reached his or her predetermined target heart rate within 3 to 4 mirutes from the start of exercise. That level was maintained within plus or minus 5 beats during the entire exercise period. A heart rate 60% of the way between the resting and maximal rate is considered the critical threshold value for intensity in order to achieve an aerobic training effect. This procedure was designed to take into account each individual's level of fitness so that he or she was exercising at a heart rate compatible with that level and yet also

provide a consistent standard for all subjects. Heart rate was constantly monitored and a corresponding change in the speed of the treadmill was made. These values were recorded every 5 minutes during the exercise period.

Following a brief rest after exercise, the STAI (Forms X-1 and X-2) was readministered. A second fingerprint impression was then made for the enumeration of open sweat pores.

Consisting of 40 brief statements -- 20 to assess a person's feelings at a particular moment and 20 to assess general feelings, the items of the State-Trait Anxiety Inventory are presented in counterbalanced order relative to anxiety. The scoring keys reverse the direction of the non-anxiety items so that a high score implies high state or trait anxiety. Scores for each form can range from 20 to 80.

For the enumeration of open sweat pores, the ring finger tip of the nondominant hand was wiped with a tissue to remove residual sweat. A thin layer of a solution of polyvinyl formal, butyl phthalate, semi-colloidal dispersion of graphite in trichloethylene and ethylene dichloride was applied from the container with a single dab of the stopper. After the solution dried, the finger was covered with a piece of Scotch "Magic" transparent tape applied and removed proximal to distal. The tape was then placed directly on a microscopic slide. For scoring, the print was enlarged 10 diameters with a microprojector. A white scoring template of proper size to represent a 4 sq. mm. area of skin surface was positioned under the central whorl. Active sweat glands, which appear as open pores along the ridges of the fingerprint, were counted.

The Statistical Package for the Social Sciences (SPSS) was utilized to perform all statistical calculations. Significance was tested at the .05 level. A t-test for dependent samples was computed to determine differences within the entire group from pre-exercise to post-exercise on the variables of state anxiety, trait anxiety, and number of open sweat pores. A t-test for independent samples was computed to determine if any between-sex differences occurred.

RESULTS AND DISCUSSION

Exercise data is presented in Table 1. Females had an average resting heart rate of 70.1 and a mean target heart rate of 144.9 beats per minute. The average resting heart rate for males was 60.8 with a mean target rate of 142.0 beats per minute. Average exercising heart rate for both males and females was within one beat of the target. Resting, target and average exercising heart rates all indicated a significant difference between the sexes. Females averaged 4.4 mph of treadmill speed while males averaged a significantly faster 5.0 mph.

Table 1

Exercise Data

	Males		Females			
	x	Sd	x	Sd	t	prob
RHR	60.8	10.4	70.1	8.9	3.02	0.01
Target HR	142.0	5.1	146.1	4.6	2.63	0.01
Av Ex HR	142.9	4.3	143.9	4.8	2.76	0.01
Av MPH	5.0	0.7	4.4	0.7	2.73	0.01

N = 20 Males and 20 Females

The data concerning the Palmar Sweat Index, utilized as a physiological indicator of stress, is presented in Table 2. The decrease in the PSI for the group as a whole from a mean of 58.3 open sweat pores before exercise to a mean of 42.9 immediately after exercise was statistically significant. The reduction of open sweat pores for both females (57.7 to 47.1) and males (58.9 to 44.6) from pre- to post-exercise was significant.

Table 2

Palmar Sweat Index

		N	x	Sd	Se	t	prob
T Grp	Pre	39	58.3	15.0	2.4	8.38	0.00
	Post		42.9	13.2	2.1		
Females	Pre	19	57.7	16.4	3.7	6.30	0.00
	Post		41.1	10.0	2.2		
Males	Pre	20	58.9	13.9	3.1	5.48	0.00
	Post		44.6	15.8	3.5		

No evidence could be found on investigations comparing the number of open sweat pores as measured by the Palmar Sweat Index before and after exercise. The entire group as well as males and females significantly decreased the number of open sweat pores after exercise. Thus, if the Palmar Sweat Index can be used as a physiological measure of stress, exercise effectively reduced stress for both sexes and to a slightly greater degree for females.

Feelings of psychological stress were measured by the State-Trait Anxiety Inventory. For the entire group, state

anxiety (Table 3), or the tension perceived and expressed by the individual at a particular point in time, decreased from a mean of 34.8 to 29.3, which was significant. Females decreased from 34.1 to 30.3 in the number of open sweat pores from before and after exercise while males showed a larger decrease from 35.5 to 28.4. Although the decreases for both males and females from pre- to post-exercise were significant, differences between the sexes on state anxiety before or after exercise were not.

Table 3

State Anxiety

		N	x	SD	Se	t	prob
T Grp	Pre	40	34.8	7.9	1.2	4.71	0.00
	Post		29.3	7.7	1.2		
Females	Pre	20	34.1	7.4	1.6	2.19	0.04
	Post		30.3	9.4	2.1		
Males	Pre	20	35.5	8.5	1.9	4.82	0.00
	Post		28.4	5.7	1.2		

The group as a whole as well as both males and females significantly reduced state anxiety, or stress felt at that particular time, as measured by the STAI Form X-1. These findings of reduced state anxiety after a single exercise period were consistent with findings by Morgan and others.10,1,2,5

On the more stable trait anxiety or general "anxiety proneness" characteristic of the individual (Table 4), the entire group decreased slightly from a mean of 32.6 before exercise to a mean of 31.3 after exercise ($p<.05$). Females did not change

significantly in trait anxiety while the reduction for males from 32.0 to 30.4 was significant. Even though statistically significant, these changes were very small and probably do not hold a great deal of psychological significance considering a 60-point range of possible scores. There were no significant differences between the sexes in the pre- and post-exercise data of trait anxiety characteristics.

Table 4

Trait Anxiety

		N	x	Sd	Se	t	prob
T Grp	Pre	40	32.6	5.7	0.9	2.47	0.02
	Post		31.3	6.6	1.0		
Females	Pre	20	33.2	6.2	1.3	1.16	0.26
	Post		32.1	7.8	1.7		
Males	Pre	20	32.0	5.3	1.1	2.77	0.01
	Post		30.4	5.3	1.1		

The fact that both males and females averaged only one beat above target heart rate during exercise implies that the subjects were working at the minimum aerobic threshold and that benefits derived as indicated in the results were obtained from easy to moderate exercise. Males displayed a lower average heart rate during exercise at a faster speed which was significantly different from females.

Within the limitations and design of this study, it was concluded that stress is effectively reduced through a single 30-minute period of exercise at the minimum aerobic threshold.

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